Reg. No. :

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B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Fifth Semester

Electronics and Communication Engineering

EC 8553 — DISCRETE – TIME SIGNAL PROCESSING

(Common to : Biomedical Engineering / Computer and Communication Engineering / Electronics and Telecommunication Engineering / Medical Electronics)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. The DFT $X(k)$ of the sequence $x[n]$ is $\{0,1+j,1,1-j\}$. Find the DFT of $y[n]=\cos\left(\frac{\pi}{2}n\right)x[n]$ using frequency shift property.

2. Interpret bit reversal and in-place computation as applied to FFT.

3. Compare Butterworth and Chebyshev filters with respect to their magnitude response and location of poles.

4. What is the effect of warping on magnitude response of digital IIR filter?

5. A system with transfer function $H(z)$ has impulse response $h(n)$ defined as $h(2)=1, h(3)=-1$ and $h(n)=0$ otherwise. Show that $H(z)$ is a FIR High Pass filter.

6. What is the effect of having abrupt discontinuity in frequency response of FIR filters?

7. The filter coefficient $H=-0.673$ is represented by sign-magnitude fixed point arithmetic. Find the quantization error due to truncation if the word length is 6 bits.

8. Interpret the statement "Rounding is preferred than truncation in realizing the digital filter".

9. Name the functional units in a Digital Signal Processor and list their features.

10. Illustrate circular buffering in DSPs with an example.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Explain any four properties of DFT. (7)

(ii) Find the 8-point DFT of the sequence $x[n] = \{0,1,2,3,4,5,6,7\}$ using Decimation in Frequency FFT algorithm. (6)

Or

(b) (i) Explain the Radix-2 Decimation in Time FFT algorithm. (7)

(ii) Find the linear convolution of finite duration sequence $h[n] = [1,2]$ and $x[n] = [1,2,-1,2,3,-2,-3,-1,1,1,2,1]$ using overlap save method. (6)

12. (a) (i) Utilize Bilinear transformation to design a digital Chebyshev filter for the following specifications (7)

$$0.707 \le \left|H(e^{j\omega})\right| \le 1 \qquad 0 \le \omega \le 0.2\pi$$

$$\left|H(e^{j\omega})\right| \le 0.1 \qquad 0.5\pi \le \omega \le \pi$$

Assume $T = 1$ sec.

(ii) Make use of direct form I and direct form II structures to realize the system.

$y[n] = -0.1y[n-1] + 0.2y[n-2] + 3x[n] + 3.6x[n-1] + 0.6x[n-2]$ (6)

Or

(b) (i) Describe the steps to design a digital filter using the Impulse Invariance Method. (7)

(ii) Using impulse invariance method, determine $H(z)$ for the analog transfer function $H(s) = \dfrac{1}{s^2 + \sqrt{2}s + 1}$. Assume $T = 1$ sec. (6)

13. (a) Use frequency sampling method to determine the impulse response $h(n)$ of a filter with $N = 7$. The desired response is given by (13)

$$H_d(\omega) = \begin{cases} e^{-j3\omega} & 0 \le |\omega| \le \frac{\pi}{2} \\ 0 & \frac{\pi}{2} \le |\omega| \le \pi \end{cases}$$

Find the transfer function of the filter and model it using minimum number of multipliers.

Or

(b) (i) Explain the steps in the design of linear phase FIR filters using Fourier series method. (7)

(ii) Model the transfer function of FIR filter $H(z) = 1 + \frac{3}{4}z^{-1} + \frac{17}{8}z^{-2} + \frac{3}{4}z^{-3} + z^{-4}$ using direct form and cascade form realization. (6)

14. (a) Interpret the effect of Quantization errors in computation of DFT and FFT algorithms. (13)

Or

(b) An LTI system is characterized by the difference equation $y(n) = 0.95y(n-1) + x(n)$. Infer the limit cycle behavior and determine the dead band of the system when (13)

$$x(n) = \begin{cases} 0.875 & for\ \ n = 0 \\ = 0 & otherwise \end{cases}$$

Assume that the product is quantized to 4 bits (excluding sign bit) by rounding.

15. (a) With flow diagram, describe the data path and MAC unit in a DSP Processor. (13)

Or

(b) Classify the addressing modes used in digital signal processors and explain them with examples. (13)

PART C — (1 × 15 = 15 marks)

16. (a) Using Hamming window, design an ideal High pass filter for the frequency response (15)

$$H_d(e^{j\omega}) = 1 for \frac{\pi}{4} \leq |\omega| \leq \pi$$

$$= 0 for |\omega| \leq \frac{\pi}{4}$$

Compute the values of $n(n)$ for N = 11 and determine its transfer function H(z).

Or

(b) Design a digital Butterworth filter to satisfy the following constraints using bilinear transformation. Assume T = 1s. (15)

$$0.9 \leq |H(e^{j\omega})| \leq 1 \text{ for } 0 \leq \omega \leq \pi/2$$

$$|H(e^{j\omega})| \leq 0.2 \text{ for } 3\pi/4 \leq \omega \leq \pi$$

Analyze the poles of the transfer function obtained and assess the stability of the filter.

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